**TELKOMNIKA Telecommunication, Computing, Electronics and Control**
Vol. 18, No. 6, December 2020, pp. 2886~2893
ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
DOI: 10.12928/TELKOMNIKA.v18i6.16331 

# Medical remotely caring with COVID-19 virus infected people using optimized wireless arm tracing system

**Mohammed Azher Therib[1], Ahmed Fahem Al-Baghdadi[2], Heyam A. Marzog[3]**
[1,3]Engineering Technical College, Al-Furat Al-Awsat Technical University, Iraq
[2]Najaf Technical Institute, Al-Furat Al-Awsat Technical University, Iraq

**Article Info**

***Article history:***

Received Apr 11, 2020
Revised May 22, 2020
Accepted Jun 12, 2020

***Keywords:***

COVID-19
Kalman filter
PID controller
PSO
Robotic arm
Wireless

**ABSTRACT**

A human arm makes many functions that a robotic arm always programmed to make same functions. The human limbs motion can be captured using sensors that they will always copy hand movement. The rapid spread of the Coronavirus (COVID-19) virus and contacting the infections make the number of patients doubled in short time. The system proposed in this research can protect clinicians against infection with virus by reducing the contact with the infected and treat them remotely. This system type can be useful in different other fields of industrial works and defense where dangerous and delicate task can be done remotely without actual touch. Xbee shield is used to allow a hand glove flex sensor to communicate with the robotic arm using Zigbee wirelessly. Zigbee here is based on Xbee module from Max stream that can be communicate outdoor for 300 feet with the line of sight and indoor for 100 feet. Proportional, integral and derivative (PID) controller used in the proposed system to achieve smooth movement of limbs. The desired signal comes from flex sensor that connected to each limb. Kalman estimator proposed to find current state of each limb. In order to get better performance, particle swarm optimization (PSO) is used.



***Corresponding Author:***

Mohammed Azher Therib,
Department of Avionics Engineering, Engineering Technical College/Al-Najaf,
Al-Furat Al-Awsat Technical University,
Najaf – Kufa – 31001, Iraq.
Email: coj.moh6@atu.edu.iq

## 1. INTRODUCTION

Corona virus is one of the new Corona virus family, where most cases of infection appeared in the Chinese city of Wuhan at the end of December 2019 in the form of acute pneumonia. The main purpose of this work is to protect all the workers in healthcare especially doctors from infection by Corona virus while they treat patients. Nowadays, robots can be used in many applications and areas as in medicine and industries. Thus, one type of robots is used in this work to implement the solution to the healthcare system with the virus-infected peoples using wireless signals to prevent doctors' infection. Robot end effectors are designed to do multiple tasks because it make it with high performance and high speed. Naturally, repeated tasks is bored for human so the best alternative is a robot [1].

Service robotics play important role in a human life. Rebotic grapser as an example make the everyday life of people who lost their arm or arms much easier [2, 3]. In today's society, the graspers not only make multiple functions, but also have a design with low cost. People for these reasons always use artificial limbs with a lower fuctions and the others that looks more humanlike and with no any function at all [4]. The industries applications also prefer a grapser that can make many works in the same time and the others with lower cost. For these esthetic reasons, the needage to cheaper robotic grapser that can do many tasks compared to everyday grasps is necessary [5, 6].

The main aim of the work is to reduce the number of infections by coronavirus and protect the doctors from infection by making a glove embedded with many sensors to copy the gestures of hand and finger, and implement them in different things, like moving robotic arm and many more [7, 8]. Also, it is important to make the movement of robot smooth as possible. In some cases, a path planning is needed to avoid collision with obstacles or other robots or other parts of the same robot. All the requirements mentioned above cannot be achieved without using latest technologies and algorithms, for example, particle swarm optimization (PSO) or any other optimization algorithms, can make it compatible with proportional, integral and derivative (PID) controller to increase the quality of the response based on fitness function. Fitness function can contained multiple functions for better description of the desired response based on application.

There are multiple estimators can be used with this work. Kalman filter is used based on multiple tests. It gives good performance with the flux sensor. The authors of [9] develop a method of sensing and control hand of robot based on EMG sensor. The system can sense two cases of each finger (thumb) of four-finger hand which are open and close. The authors of [10] develop a control system for an arm of robot with 6 degree of freedom. Their proposed system is simple and cheap as compared to the other systems. They use Python software because it free, simple and develop a reliable software control.

Adaptive command-filtered backstepping control (CFBC) is designed for the robot arm. Backstepping is a non-linear control method. The stability of the controller examined by Lyapunov method [11, 12]. A lightweight 5 degree of freedom robot arm was designed and implemented in [13] in order to use it on the quadcopter for multiple purposes. PSO is used in [14] with neural network (NN) for kinematic parameter identification. Multiple control methods were used for joints of robots like PID as a linear method or backstepping as a non-linear method as mentioned by different works [15-18].

## 2. PARTICLE SWARM OPTIMIZATION (PSO)

PSO is one of the smart optimization algorithms. It's belongs to Metaheuristics which is one of the classes of optimization algorithms [19, 20]. It is based on praline swarm intelligent and is inspired by the animals' behaviors as birds or fish. PSO is an easy type of optimization algorithms that is used in many applications in different fields as engineering and science for example, data mining, image processing, machine learning and various other fields [21, 22]. Initially, PSO introduced by James Kennedy and Russell C. Eberhert in 1995 [23]. At the beginneing, they were working for developping a model to describe the animals' social behaviors as school of fish. Then, they realize their models, which are capable of doing different tasks of optimization [24]. In last twenty years, PSO became one of the most famous useful algorithms that it can solve different problems of optimization in different fields. One of the key points behind the PSO is that it easy to implement [25]. Actually, PSO is a powerful algorithm and very simple to use. Figure 1 and Figure 2 explain the operation of PSO algorithm as flowchart and pseudocode respectively.

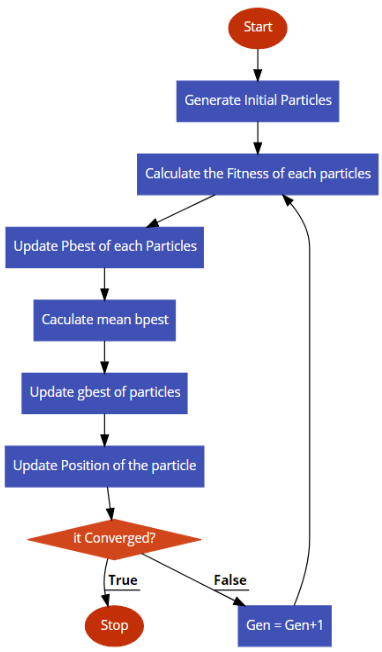



Figure 1. Flowchart of PSO algorithm

```
Start;
Generate Initial Particles;
a:Calculate the Fitness of each particles;
Update Pbest of each Particles;
Caculate mean bpest;
Update gbest of particles;
Update Position of the particle;
if (it Converged?)
{
 Stop;
}
else {
Gen = Gen+1;
goto a
}
```

Figure 2. Pseudocode of PSO algorithm

## 3. KALMAN FILTER

It is a mathematical iterative process that use a set of consecutive data and equations that quickly input to estimate the true value like velocity, position, etc of the measured object, when the measured value is random error uncertainty or vibration or unpredicted [26-28]. Figure 3 shows the block diagram of the process of Kalman filter. Here, three main equations need to be done. The first equation is to find the gain of the Kalman filter. The second equation is to find an estimated value of current. The third equation used to find the last estimation error. These three calculations are repeated continuously to improve the current estimated value. To calculate the gain of the Kalman filter, two parameters must be available. The first one is the error of estimation. At first, the error estimation value must inserted and then come from third equation repeatedly. The second parameter is the error in measured data. The Kalman filter gain is really put the error in the data measured versus the error in the estimate. If the error in the estimate is small, the gain put the most important in it and vice versa. The current estimate is found based on input data in addition to previous estimate. The new error estimate is found based on the gain of the Kalman filter and the current estimate value. This process repeated continuously to decrease the error and get the true value. Figure 3 explain the block diagram of the mentioned filter while Figure 4 describe the operation of Kalman filter as a loop. The data from the flex sensors in this work filtered using Kalman filter loop of operation to estimate real desired states.

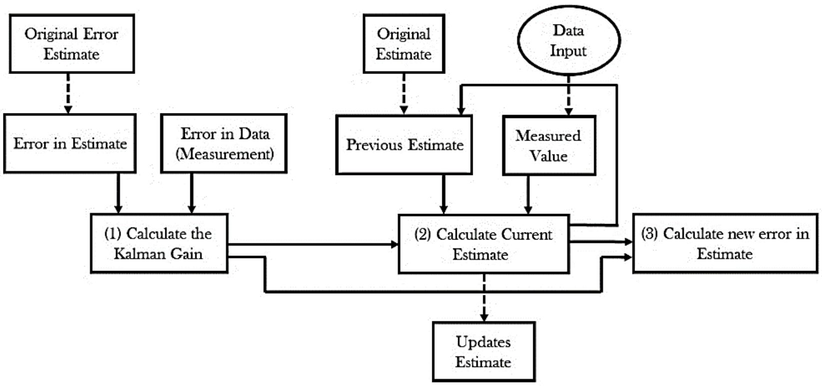



Figure 3. Block diagram of Kalman filter

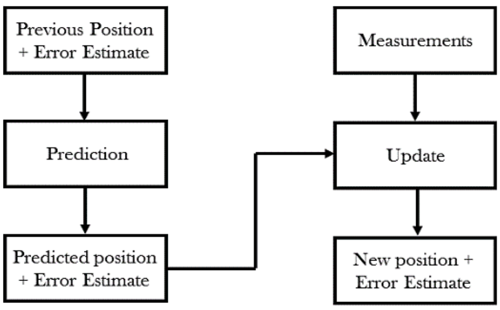



Figure 4. Loop operation of Kalman filter

## 4. PROPOSED SYSTEM

In this system, we made a wireless control for robotic arm using optimized PID controller and Kalman filter. A flex sensor is connected with each limb according to Figure 5. Arduino is used to get the signal of each flex sensor. The received signal was filtered using Kalman filter in order to get better estimation of current state in state of noisy data getting before. The feedback data come from similar sensors connected with the limb of robotic arm as shown in Figure 6.

Figure 5. Flex sensor connected to each limb

Figure 6. Flex sensor connected to the robot arm

The parameters of PID controllers optimized using PSO algorithm according to the block diagram shown in Figure 7. The overall system can be described in the following steps:

Step1: Install the system according to the circuit shown in Figure 8.
Step2: Get the desired states from flex sensors that connected to the human limbs. The data received from analog terminals of Arduino. Change the flex sensor angle leads to change in output voltage of the voltage divider. The output voltage changes from 0-5 V converted to a digital form with range 0-1024. The accuracy of inversion is 0.4%.
Step3: The data from step 2 filtered using Kalman filter to estimate real desired states.
Step4: Send filtered data gotten from step 3 to the robot side wirelessly using ZigBee protocol or internet.
Step5: Repeat steps 2, 3 and 4 endlessly with 1 sec. interval.

In the other side (side of the robot), the system works as following steps:

Step1: Receive the desired data sent from the human side.
Step2: Get the actual states of the robot using flex sensor that connected to the limb of the robot (same procedure of step2 in the human side to get the actual states).
Step3: Compute the error signal based on desired and actual values.
Step4: Use PID controller to generate output signal used by actuators (servo motors) to change the states of limbs in order to decrease error signal.
Step5: Repeat all steps before endlessly within 1 sec. interval.

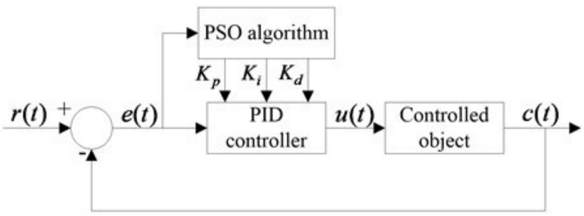



Figure 7. Block diagram of PID parameter setting

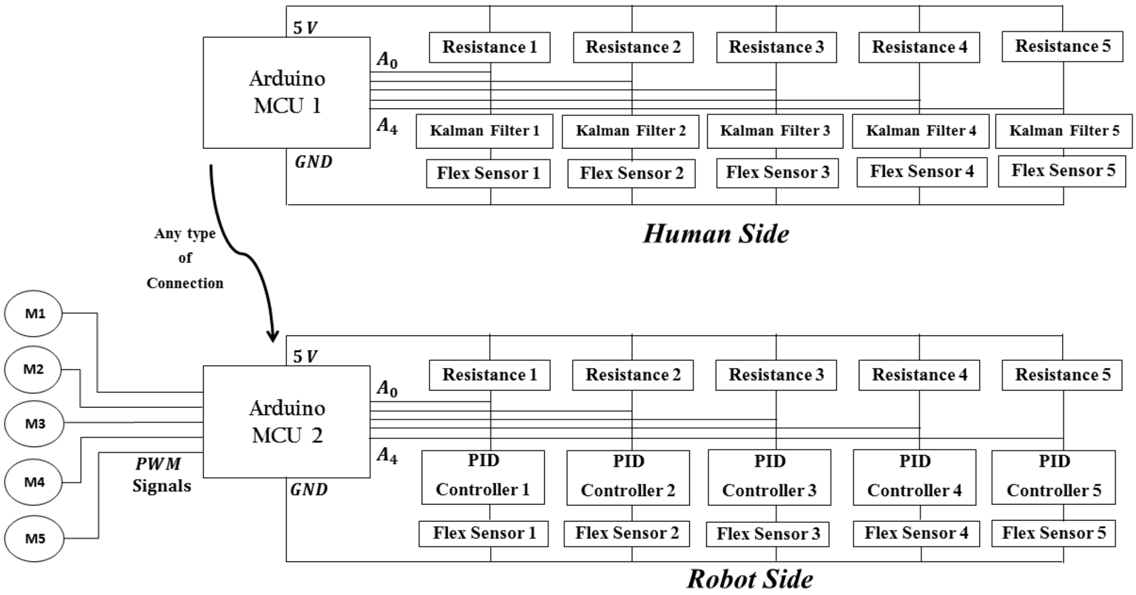



Figure 8. Block diagram of the implemented circuit

## 5. RESULTS

The flex sensors were subjected on the glove that the doctor will wear it by hand and they will copy the movement of his fingers. The angles of these flex sensors will be transmitted used ZigBee protocol using XBee module shield that put-on Arduino board. This human side is shown in Figure 9. The robotic arm shown in Figure 10 was used in this work to recive the angles data from the Xbee module which are the data get from flex sensors and treat the infected-people directly. The implemented robot side was shown in Figure 10.

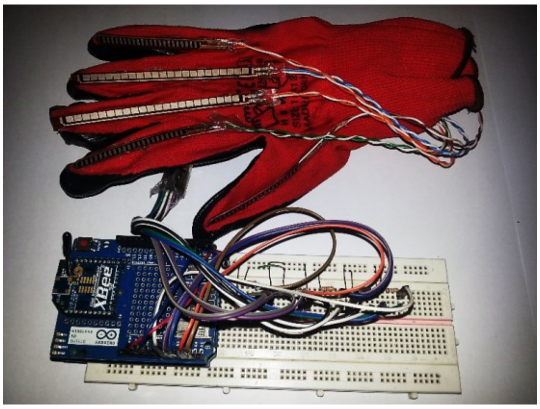


Figure 9. Human side

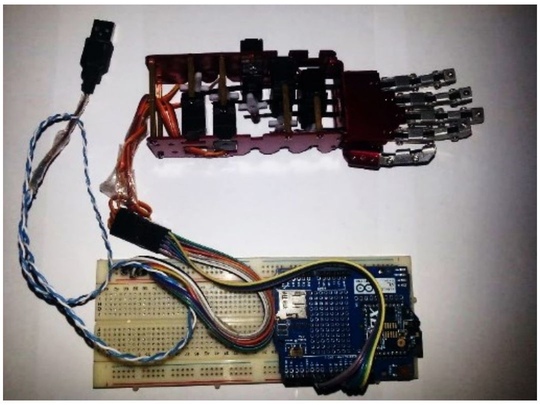


Figure 10. Robot side

This tranciever system (human and robot sides) was tested in multiple scenarios and give high performane to treat people remotely using ZigBee protocol based on XBee module when examined practically. The optimized PID controller is an efficient controller for these types of systems. The step response without optimization of each finger was tested using Matlab simulation and is shown in Figure 11. In this response, the rise time and settling time is very high, and the response did not reach the maximum overshoot. In Figure 12 the tuning or improved response to the desired is demonstration. The desired response that get after optimization process was shown in Figure 13. In this improved response, the rise time is 1.2 sec. and settling time is 1.6 sec. which is better than the response without optimization. The maximum overshoot in this curve is 1.1 at 1.3 sec. Table 1 summarize the step respose specifications of optimized PID controller.

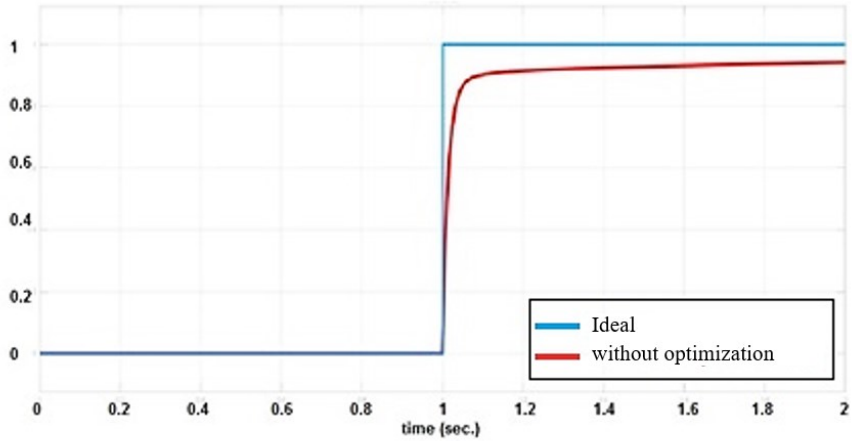



Figure 11. Step response without optimization

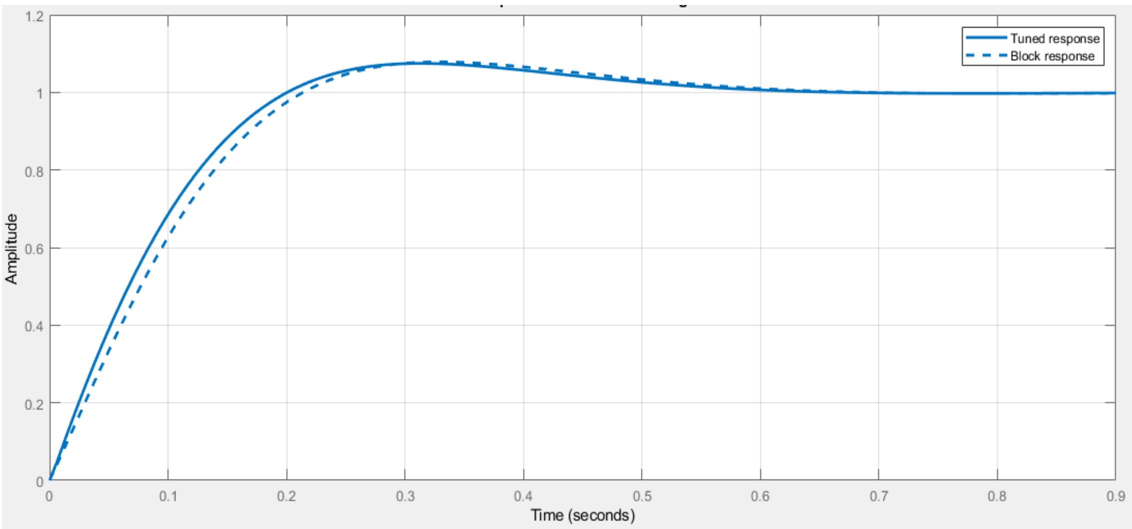



Figure 12. Tuning of PID parameter

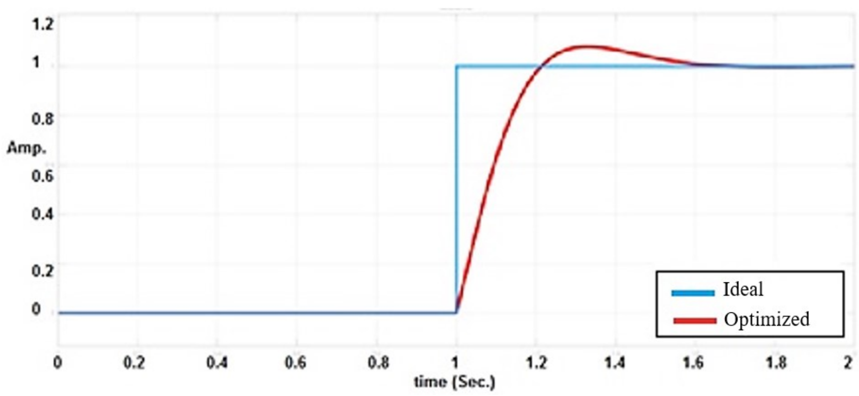



Figure 13. Step response of an optimized PID controller

Table 1. Step response specifications of an optimized PID controller

| Rise time | Settling time | Maximum Overshoot | Peak time |
|---|---|---|---|
| 1.2 | 1.6 | 1.1 | 1.3 |

## 6. CONCLUSIONS

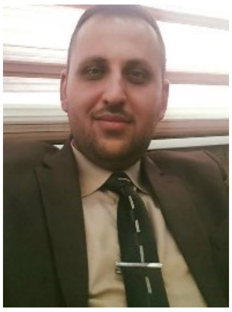
The proposed system works with high performance and high accuracy in its final version when it was examined practically in healthcare centers. PSO and Kalman filter improve the performance of the system significantly. The flex sensor works with high frequency response but its output is noisy, so Kalman filter is proposed to overcome this weak point of the sensor. Small bitrate is enough to transmit data needed to control the robot wirelessly, so the weakness of internet in many regions like Iraq did not interrupt the work of the system. Another advantage of Kalman filter in this system is to overcome loss data in small interval. The system still behaves stable.

## REFERENCES

[1] A. Bicchi and G. Tonietti, “Fast and ‘soft-arm’ tactics [robot arm design,” *IEEE Robot. Autom. Mag*., vol. 11, no. 2, pp. 22-33, 2004.
[2] R. Ham, T. G. Sugar, B. Vanderborght, K. W. Hollander, and D. Lefeber, “Compliant actuator designs*,” IEEE Robot. Autom. Mag.,* vol. 16, no. 3, pp. 81-94, Sep. 2009.
[3] X. Li, Y. Pan, G. Chen, and H. Yu, “Multi-modal control scheme for rehabilitation robotic exoskeletons,” *Int. J. Robot. Res.,* pp. 1-20, 2017.
[4] Ibrahim Sulaiman, Engr. Salam M. O. and Yamajin Tanimu, “Development of A Robot Arm: A Review,” *The Federal Polytechnic Bida, School of Engineering Technology, 8th National Engineering Conference,* 2018.
[5] Vishnuvarthanan Govindaraj, *et al.*, "Robotic Arm for the Easy Mobility of Amputees using EMG Signals,” *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, vol. 9, no. 2S2, pp. 29-931, 2019.
[6] Dishant Khosla, Manvinder Sharma, Sachin Krishan Khanna, Pratibha Khanna, Gurpreet Kaur, “Smart Robotic Arm Review,” *Journal of Artificial Intelligence Research & Advances*, vol. 6, no. 2, pp. 58-62, 2019.
[7] Raghul B., *et al.*, “Iot Enabled Robotic Arm,” *International Journal of Research in Electronics*, vol. 05, no. 01, pp. 11-13, 2018.
[8] Mohammed Azher Therib *et al.,* "Smart Digital Bi-Directional Visitors Counter Based on IoT,” *Journal of Physics Conference Series,* May, 2020.
[9] S. Bitzer, P. van der Smagt, “Learning EMG control of a robotic hand: Towards Active Prostheses,” *IEEE International Conference on Robotics and Automation*, pp. 2819-2823, 2006.
[10] D. Rivas, *et al.*,"control system for a robotic arm with 6 degrees of freedom for education systems,” 6th *International Conference on Automation, Robotics and Applications*, pp. 358-363, 2015.
[11] Y. Pan, *et al.*, “Adaptive Command-Filtered Backstepping Control of Robot Arms with Compliant Actuators,” *IEEE transactions on control systems technology*, vol. 26, no. 3, pp. 1149-1156, 2017.
[12] J. A. Farrell and M. M. Polycarpou, “Adaptive Approximation Based Control: Unifying Neural, Fuzzy and Traditional Adaptive Approximation Approaches,” *Hoboken*, NJ, USA: Wiley, 2006.
[13] C. D. Bellicoso, L. R. Buonocore, V. Lippiello, B. Siciliano, “Design, Modeling and Control of a 5-DoF Light-Weight Robot Arm for Aerial Manipulation,” *23rd Mediterranean Conference on Control and Automation MED,* 2015.
[14] G. Gao, F. Liu, H. San, X. Wu, W. Wang, “Hybrid Optimal Kinematic Parameter Identification for an Industrial Robot Based on BPNN-PSO,” *Hindawi,* pp 1-11, 2018.
[15] A. de Luca, B. Siciliano, L. Zollo, “PD control with on-line gravity compensation for robots with elastic joints: Theory and experiments,” *Automatica*, vol. 41, no. 10, pp. 1809-1819, 2005.
[16] A. R. Al Tahtawi, M. Yusuf, "Low-cost quadrotor hardware design with PID control system as flight controller," *TELKOMNIKA Telecommunication, Computing, Electronics and Control,* vol. 17, no. 4, pp. 1923-1930, 2019.
[17] M. A. Asker, E. I Essa, A. A. Ali, K. S. Gaeid, “Fuzzy PID Controller for Induction Motor with DSP Wavelet,” *REVISTA AUS* 26-1, pp. 1-7, 2019.
[18] F. S. M. Alkhafaji, W. Z. Wan Hasan, M. M. Isa, N. Sulaiman, “A Novel Method for Tuning PID Controller,” *Journal of Telecommunication, Electronic and Computer Engineering*, vol. 10, no. 1-12, pp. 33-38, 2020.
[19] Gusti Alfarisy, Wayan Mahmudy and Muhammad Natsir, " Optimizing Laying Hen Diet using Multi-swarm Particle Swarm Optimization," *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 16, no. 4, pp. 1712-1723, 2018.
[20] T. Winarno, L. Palupi, A. Pracoyo, L. Ardhenta, “MPPT control of PV array based on PSO and adaptive controller,” *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 18, no. 2, pp. 1113-1121, 2020.
[21] Y. Sari, E. Wijaya, A. Baskara, R. D. Kasanda, “PSO optimization on backpropagation for fish catch production prediction,” *TELKOMNIKA Telecommunication, Computing, Electronics and Control,* vol. 18, no. 2, pp. 776-782, 2020.
[22] D. Wang, D. Tan, L. Liu, “Particle swarm optimization algorithm: an overview,” *Springer Soft Comput,* vol. 22, pp. 387-408, 2018.
[23] P. Sutyasadi, M. B. Wicaksono, “Joint control of a robotic arm using particle swarm optimization based H2/H∞ robust control on Arduino,” *TELKOMNIKA Telecommunication, Computing, Electronics and Control,* vol. 18, no. 2, pp. 1021-1029, 2020.
[24] Y. Zhang, S. Wang, G. Ji, “A Comprehensive Survey on Particle Swarm Optimization Algorithm and Its Applications,” *Hindawi Publishing Corporation, Mathematical Problems in Engineering,* vol. 2015, pp. 1-38, 2015.
[25] A. Shihab Ahmed, *et al.*, “A robust Image Watermarking Based on Particle Swarm Optimization and Discrete Wavelet Transform,” *REVISTA AUS* 26-1, pp. 150-158, 2019.
[26] T. Yamauchi, “Modeling Mindsets with Kalman Filter,” *Mathematics,* pp. 1-18, 2018.

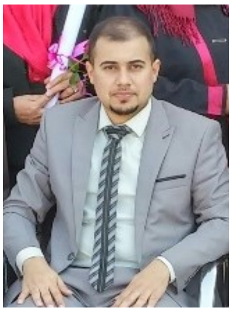
[27] S. Amin, H. Ahmad, M. Mohamed, M. Saari, O. Aliman, "Kalman Filter Estimation of Impedance Parameters for Medium Transmission Line," *TELKOMNIKA Telecommunication, Computing, Electronics and Control*, vol. 16, no. 2, pp. 900-908, 2018.
[28] Y. Kim, Hyochoong Bang, "Introduction to Kalman Filter and It's Applications," *IntechOpen*, 2018. DOI: 10.5772/intechopen.80600

## BIOGRAPHIES OF AUTHORS



**Mohammed Azher Therib,** Assistant Lecturer at Engineering Technical College/Al-Njaf, Al-Furat Al-Awsat Technical University, Iraq. He was born in 1988 in Iraq. He obtained his bachelor's B.Sc. degree in Electrical Engineering from Babylon University, Iraq in 2009-2010. Then, he obtained his Master M.Sc. degree in Electrical Engineering/ Electronic and Communications from Electrical Engineering Department in Babylon University at 2013-2014. His fields of interest include Electronic, Power Electronics, Coding, Security, IoT, Control, Optimization and Wireless Communications.

**Heyam A. Marzog,** Assistant Lecturer at Engineering Technical College/Al-Njaf, Al-Furat Al-Awsat Technical University, Iraq. She was born was born in 1978 in Iraq. She obtained her Bachelor's degree in communication Engineering from technical college of Najaf Al-Furat al-Awsat University in 2002, and the MSc degree in Electrical Engineering (communication system) in 2012 from the University of Tenaga National in Malaysia. Her fields of interest include the security and saving energy of Wireless Communication Networks and their application to Energy Management Systems, Control and Optimization. Also, her current field of interest internet of things.



**Ahmed Fahem Al-Baghdadi,** Lecturer at Najaf Technical Institute, Al-Furat Al-Awsat Technical University, Iraq. He was born in 1991 in Iraq. He recieved the bachelor B.Sc. degree in Electrical Engineering from Babylon University, Iraq in 2011-2012. Then, he complete hiss Master M.Sc. degree in Electrical Engineering/Electronic and Communications from Electrical Engineering Department in Babylon University at 2014-2015. He gets a PHD degree in Electrical Engineering from Al-Basra University, Iraq at 2020.